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(71) Applicant: EMHART INC.
Newark, Delaware 19711 (US)

(72) Inventors:
- Mauer, Dieter
35457 Lollar (DE)
- Roser, Hermann
35444 Biebertal (DE)

(74) Representative:
Shaya, Darrin Maurice et al
Black & Decker,
Patent Department,
210 Bath Road
Slough SL1 3YD (GB)

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(54) Process for forming a punch rivet connection and a joining device for punch rivets

(57) The invention relates to a process for forming a punch rivet connection and to a joining device, a plunger (4) and optionally a holding-down device (5) being driven via a transmission unit (2). The transmission unit (2) converts a rotational movement of an electric motor drive unit (1) into a translation movement of the plunger (4) or of the holding-down device (5).

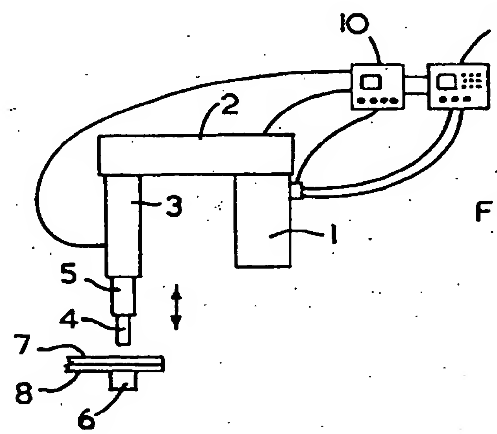

FIG. 1

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Description

[0001] This application is a divisional application based upon European Patent Application No. 98 305 474.3.

[0002] The invention relates to a joining device for punch rivets.

[0003] To form a punch rivet connection with which at least two parts to be joined can be connected to one another by a rivet, it is not necessary for the parts to be joined to be pre-punched. It is known that a punch rivet connection can be made using a solid rivet or hollow rivet.

[0004] A punch rivet connection is formed with a solid rivet by placing the parts to be joined on a die. A holding-down device is brought into contact with the parts to be joined above the die. The parts to be joined are clamped between the holding-down device and the die. The holding-down device is hollow in design. The rivet is arranged in it. A plunger acts on the rivet so that the plunger punches the rivet through the parts to be joined. The rivet punches a hole in the parts to be joined so the pre-punching required in conventional riveting processes is unnecessary. Once the rivet has penetrated the parts to be joined, the holding-down device presses the parts to be joined against the die which comprises a ferrule. The force of the holding-down device and the geometry of the die result in plastic deformation of the die-side part to be joined which flows partially into an annular groove in the punch rivet. The solid rivet is not deformed. The parts to be joined are reached by the geometry of the rivet head and by the die-side connection of the part to be joined to the rivet in the annular groove.

[0005] Hydraulically operated joining devices are used to form such a punch rivet connection. The plunger is actuated by a hydraulic cylinder unit. The cost of producing such joining devices is relatively high. In particular, process control for achieving high-quality punch rivet connections gives rise to problems. In particular, hydraulically operated joining devices are subject to variations in the force exerted by the plunger owing to changes of viscosity. The changes in the viscosity of the hydraulic medium are substantially dependent on temperature. A further drawback of hydraulically operated joining devices is that the hydraulic medium, which may be oil, has a hydroscopic effect so it is necessary to exchange the hydraulic fluid at predetermined time intervals.

[0006] When forming a punch connection with a hollow rivet - the same applies to a semi-hollow rivet - the hollow rivet penetrates the plunger-side part to be joined and penetrates partially into the die-side part to be joined. The die is so designed that the die-side part to be joined as well as the rivet are deformed to a closing head. An example of a design of a joining device for forming a punch rivet connection with a hollow rivet is known from DE 44 19 065 A1. Hydraulically operating joining devices are also used for producing a punch rivet connection with a hollow rivet.

[0007] The object of the present invention is to provide a punch rivet joining device which is constructionally simple in design is also to be provided.

[0008] This object is achieved according to the invention by a process having the features of the dependent claims.

[0009] According to the invention, there is provided a joining device for punch rivets with a die, a holding-down device, a plunger, a drive unit connected to the plunger, a control unit for controlling at least the drive unit and a monitoring unit is proposed in which the drive unit has electric motor action. The electric motor drive unit is connected via a transmission unit to the plunger or to the plunger and the holding-down device. As a result, the rotational movement of the electric motor drive unit is convened via the transmission unit into a translational movement of the plunger or of the plunger and the holding-down device. This design of the joining device also prevents intermittent stressing of the joining device of the type which occurs with known hydraulically operated joining devices. A further advantage of the device according to the invention is that the joining device can be used both movably and stationarily. With stationary use of the joining device, only one power connection is required for the electric motor drive unit. The joining device according to the invention can be produced economically.

[0010] The joining device is preferably so designed that the transmission unit has at least one gear. The gear is preferably a reduction gear. This has the advantage that a drive unit with a relatively low torque can be used. The relatively low torque of the drive unit is converted into a correspondingly higher torque or force on the plunger by the reduction gear as a function of the reduction ratio. The gear is preferably designed such that it has at least one predetermined reduction ratio.

[0011] According to a further advantageous idea, it is proposed that the plunger or the plunger and the holding-down device be connected to the transmission unit via a spindle drive. To avoid high frictional losses, it is proposed that the spindle drive be a circulating ball spindle drive.

[0012] The monitoring unit of the joining device according to the invention preferably has at least one sensor which serves to detect process data. It is proposed, in particular, that at least one sensor be a displacement transducer which indirectly or directly picks up the displacement of the plunger and optionally of the holding-down device during a joining procedure.

[0013] According to a further advantageous embodiment of the joining device, it is proposed that at least one sensor be a force transducer which indirectly or directly picks up the force of the plunger and optionally of the holding-down device during the joining procedure. It is proposed in particular that the force transducer have at least one piezo element. Alternatively, the

force transducer can be a load cell.

[0014] The force transducer is preferably arranged between the plunger and the transmission unit or between the holding-down device and the transmission unit. The transmission unit preferably rests on a framework. The force transducer is arranged between the transmission unit and the framework.

[0015] According to a further preferred embodiment of the joining device, it is proposed that at least one sensor measure the power consumption of the drive unit during a joining procedure.

[0016] Additionally or alternatively it is proposed that at least one sensor pick up the torque of the drive unit and/or of the transmission unit during a joining procedure.

[0017] Further details and advantages of the process according to the invention and of the joining device are described with reference to a preferred embodiment of a joining device illustrated in the drawings.

Figure 1 is a schematic view of a joining device.
Figure 2 is a section through a joining device.
Figure 3 is a force/displacement graph of a punch riveting procedure with a solid rivet.
Figure 4 is a force/displacement graph of a punch riveting procedure with a hollow rivet.

[0018] Figure 1 is a schematic view of the design of a joining device for punch rivets. The joining device has an electric motor driven drive unit 1. The drive unit 1 is connected to a transmission unit 2. A drive shaft of the drive unit 1 can be coupled to the transmission unit 2. The coupling can preferably be releasable in design so different transmission units 2 can be used. The transmission unit 2 preferably has at least one gear. This is, in particular, a reduction gear. A gear which has at least one predetermined reduction ratio is preferred.

[0019] The transmission unit is connected to a plunger 4 or to the plunger 4 and the holding-down device 5. Whether merely the plunger 4 or also the holding-down device 5 is connected to the transmission unit 2 depends on whether the joining device is used to form a punch rivet connection with a solid rivet or a hollow rivet. If the joining device is used for forming a punch rivet connection by means of a solid rivet, the holding-down device 5 is also coupled to the transmission unit 2.

[0020] The plunger 4 or the plunger 4 and the holding-down device 5 are connected to the transmission unit 2 via a spindle drive 3. The spindle drive 3 can also be part of the transmission unit 2 so they form a constructional unit. The spindle drive 3 is preferably a circulating ball spindle drive.

[0021] The plunger 4 and the holding-down device 5 are movable in the direction of the arrow shown in Figure 1. A die 6 is arranged beneath the plunger 4. Two parts to be joined 7, 8 are arranged schematically on the die 6.

[0022] The joining device also comprises a control unit 9 for controlling the drive unit 1. A monitoring unit 10 which comprises at least one sensor for detecting process data is connected to the control unit 9. A connection between the monitoring unit and the drive unit 1, the transmission unit 2 and the spindle drive 3 is shown schematically in Figure 1. The drive unit 1, the monitoring unit 2 and the spindle drive 3 can have corresponding sensors for picking up specific characteristics, the output signals of which are processed in the monitoring unit 10. The monitoring unit 10 can be part of the control unit 9, the monitoring unit 10 emitting input signals as open and closed loop control variables to the control unit 9. The sensors can be displacement and force transducers which determine the displacement of the plunger 4 and the force of the plunger 4 on the parts to be joined 7, 8. A sensor which measures the power consumption of the electric motor action drive unit 1 can also be provided.

[0023] A punch rivet is arranged within the holding-down device to form a punch rivet connection between the parts to be joined 7, 8. The plunger 4 is displaceable relative to the holding-down device 5. The plunger 4 exerts a force on a punch rivet by means of which the punch rivet connection is obtained. The drive unit 1 is set into operation for this purpose. The rotational movement of the drive unit 1 is converted via a transmission unit 2 and, in the embodiment illustrated, the spindle drive 3 into a translation movement of the plunger 4 and the holding-down device 5.

[0024] Figure 2 is a partial section through a joining device. The joining device has an electric motor operated drive unit 1. The drive unit 1 is connected to the transmission unit 2. The transmission unit 2 is arranged in an upper end region of a housing 25. The housing 25 is connected to a framework 24.

[0025] The drive shaft 11 of the drive unit 1 is connected to a belt wheel 12 of the transmission unit 2. The belt wheel 12 drives a belt wheel 14 via an endless belt 13 which may be a flexible toothed belt. The diameter of the belt wheel 12 is substantially smaller than the diameter of the belt wheel 14, allowing a reduction in the speed of drive shaft 11. The belt wheel 14 is rotatably connected to a drive bush 15. A gear with gear wheels can also be used instead of a transmission unit 2 with belt drive. Other alternatives are also possible. A rod 17a is transversely displaceable within the drive bush 15 which is appropriately mounted. The translation movement of the rod 17a is achieved via a spindle drive 3 having a spindle nut 16 which cooperates with the rod 17a. At the end region of the rod 17a remote from the transmission unit 2 there is formed a guide member 18 into which the rod 17a can be introduced. A rod 17b adjoins the rod 17a. An insert 23 is provided in the transition region between the rod 17a and the rod 17b. The insert 23 has pins 20 which project substantially perpendicularly to the axial direction of the rod 17a or 17b and engage in slots 19 in the guide member 18. This ensures that the rod 17a and 17b does not rotate. The

rod 17b is connected to a plunger 4. The plunger 4 is releasably arranged on the rod 17b so it can be formed according to the rivets used. A stop member 22 is provided at the front end region of the rod 17b. Spring elements 21 are arranged between the stop member 22 and the insert 23. The spring elements 21 are spring washers. The spring elements 21 are arranged in a tubular portion of the guide member 18. The guide member 18 is arranged so as to slide in the housing 25. Figure 2 shows the joining device in a position in which the plunger 4 and the holding-down device 5 rest on the parts to be joined 7, 8, the parts to be joined 7, 8 resting on the die 6.

[0026] In a punch rivet connection formed by a grooved solid rivet, the rivet is pressed through the parts to be joined 7, 8 by the plunger 4 once the parts to be joined 7, 8 have been fixed between the die 6 and the holding down device 5. The rivet punches a hole in the parts to be joined 7, 8 during this procedure.

[0027] The holding-down device 5 and the plunger 4 effect clinching which extends to point A of the curve in the force/displacement graph shown in Figure 3. The rivet then punches a hole in the parts 7, 8 to be joined, this procedure taking place in the portion A - B. After punching has taken place, the holding-down device presses against the parts to be joined 7, 8. The holding-down device presses against the die such that the die-side part to be joined 8 flows into the groove of the rivet owing to a corresponding design of the die 6. This portion of the process lies between points B - C.

[0028] Regions in which the actual trend of the force or a characteristic corresponding to the force as a function of the displacement can be compared with a desired trend are designated by V1, V2 and V3 in Figure 3. The regions V1, V2 and V3 are significant for the quality of the punch rivet connection. However, the entire actual trend can also be compared with the desired trend instead of selected regions V1, V2 or V3. A statement as to whether, for example, a solid rivet is arranged on the plunger-side part to be joined 7 with the correct orientation can be obtained by comparison in the region V1. A statement about the clinch behaviour of the parts to be joined can also be derived. If the clinch behaviour differs, it can be concluded that, for example, the plunger-side part to be joined consists of an incorrect material.

[0029] A statement as to whether, for example, complete punching of the parts to be joined 7, 8 has occurred can be obtained by comparison in region V2.

[0030] Comparison between the actual trend and the desired trend in region V3 provides a statement as to whether the material of the die-side part to be joined 8 has flown into an annular groove in a rivet, not shown.

[0031] The trend of the force as a function of the displacement can be determined by the process according to the invention from the power consumption of the electric motor drive 1.

[0032] Figure 4 is a schematic view of a force/displacement graph of the type produced during a punch riveting procedure using a hollow rivet. The force/displacement graph shows that essentially four process portions can be detected in the punch rivet procedure using a hollow rivet. A first process portion which essentially corresponds to a clinching procedure can be seen up to point A. A second process portion which essentially corresponds to the cutting procedure can be seen between points A and D. During the cutting process, the plunger 4 and therefore also a rivet covers a relatively great displacement s, the force exerted by the plunger 4 on the rivet being relatively constant.

[0033] Once the rivet has cut through the plunger-side part to be joined 7, the rivet is spread in the die 6 as the force of the plunger 4 increases. This portion of the process is located between points D - E of the force/displacement graph according to Figure 4. The die-side part to be joined 8 is deformed by the die 6 during this procedure.

[0034] If the force exerted on the rivet by the plunger 4 is sustained, the rivet is compressed. The compression process is shown in portion E - F in Figure 4. If the head of the punch rivet lies in the plane of the plunger-side part to be joined 7, the punch rivet connection is produced.

[0035] The force/displacement trend can be determined from the process data. With a known force/displacement trend which serves as a reference trend, the quality of a punch connection can be determined by means of the actual trend of the force as a function of the displacement.

[0036] Figure 4 shows regions H1 - H4 in which the actual trend of the force as a function of the displacement is checked with a desired trend. The regions H1 - H4 are selected at the significant transition points of the process steps, as described hereinbefore. A quality statement about the punch rivet connection can therefore be obtained. The entire actual trend can also be checked with a desired trend rather than individual regions H1 - H4, the desired trend forming a band within whose limits the actual trend is to lie.

Claims

1. A Joining device for rivets having:

   a holding-down device (5), a plunger (4), a drive unit (1) connected to the plunger (4),
   a control unit (9) for controlling at least the drive unit, a monitoring unit (10) connected to the control unit (9), an electric motor drive unit (1) connected via the transmission unit (2) to the plunger (4) and the holding-down device (5), characterised in that the joining device includes a die (6) against which die (6) the holding-down device (5) clamps material to be riveted and wherein the rivets driven by the plunger (4) are punch rivets to be driven into the material.

2. Joining device according to claim 1, characterised in that the transmission unit (2) has at least one gear.

3. Joining device according to claim 2, characterised in that the gear is a reduction gear.

4. Joining device according to one of claims 1 to 3, characterised in that the plunger (4) or the plunger (4) and the holding-down device (5) is connected to the transmission unit (2) via a spindle drive (3).

5. Joining device according to claim 4, characterised in that the spindle drive (3) is a circulating ball spindle drive.

6. Joining device according to one of claims 1 to 5, characterised in that the monitoring unit (10) has at least one sensor for detecting process data.

7. Joining device according to claim 6, characterised in that at least one sensor is a displacement transducer which indirectly or directly picks up the displacement of the plunger (4) and of the holding-down device (5) during a joining procedure.

8. Joining device according to claim 6 or 7, characterised in that at least one sensor is a force transducer which indirectly or directly picks up the force exerted by the plunger (4) and by the holding-down device (5) during a joining procedure.

9. Joining device according to claim 8, characterised in that the force transducer has at least one piezo element.

10. Joining device according to claim 8, characterised in that the force transducer is a force pickup.

11. Joining device according to claims 8, 9 or 10, characterised in that the force transducer is arranged between the plunger (4) and the transmission unit (2) and is optionally arranged between the holding down device (5) and the transmission unit (2).

12. Joining device according to claims 8, 9 or 10, characterised in that the transmission unit (2) is supported on a framework and the force transducer is arranged between the transmission unit (2) and the framework.

13. Joining device according to one of claims 6 to 12, characterised in that at least one sensor picks up the power consumption of the drive unit (1) during a joining procedure.

14. Joining device according to one of claims 6 to 13, characterised in that at least one sensor picks up the torque of the drive unit (1) and/or of the transmission unit (2) during a joining procedure.

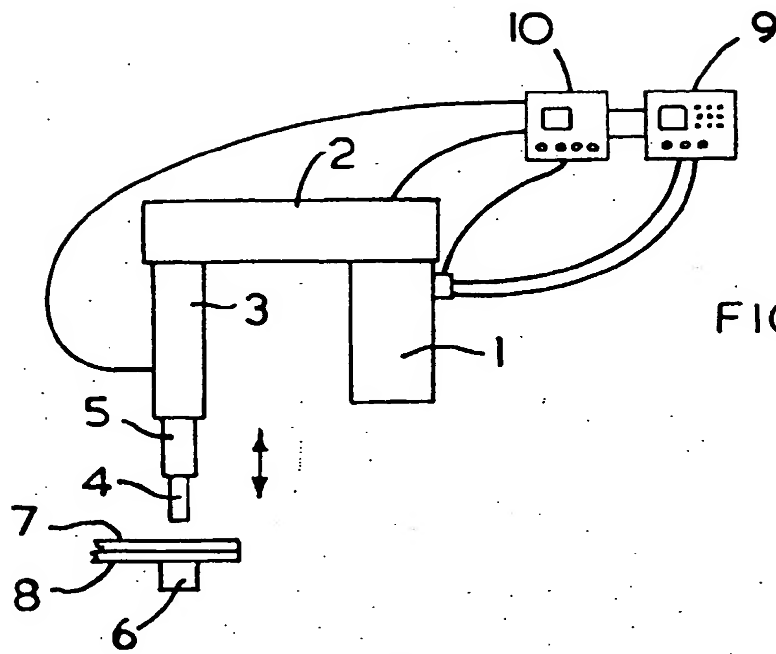

FIG. 1

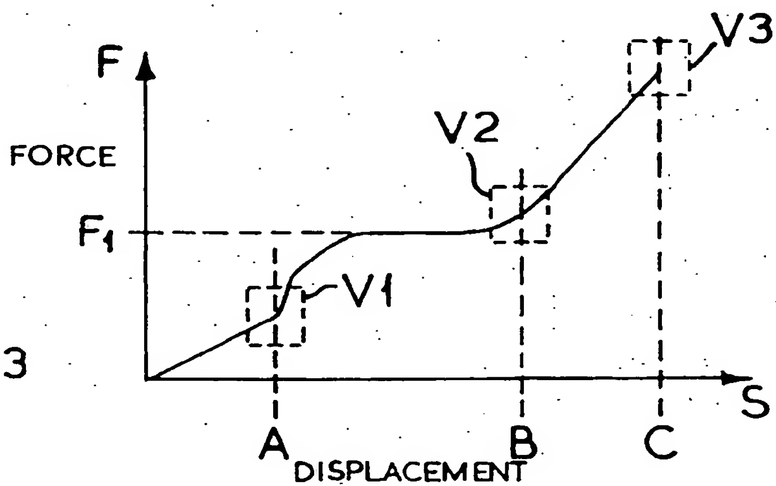

FIG. 3

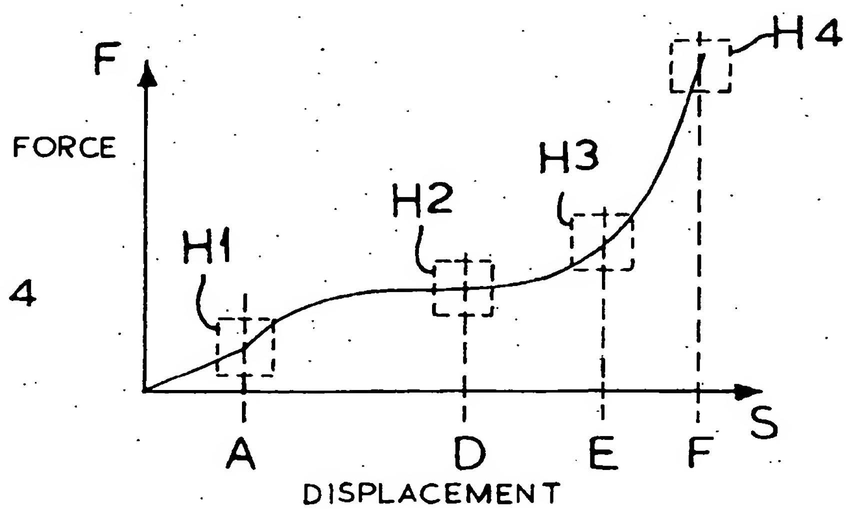

FIG. 4

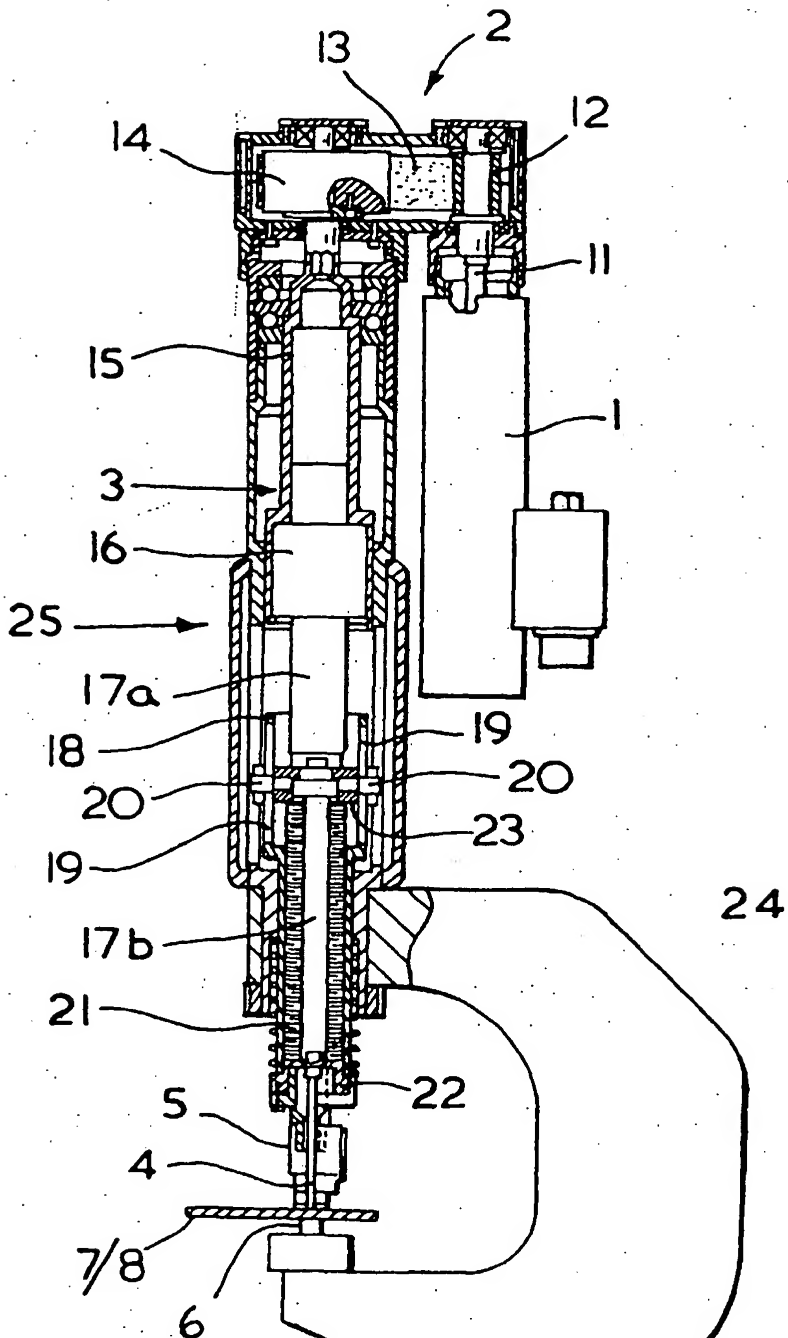

FIG. 2

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